



REV.	ZONE	ECO #	REVISION	APPD	DATE
A		F083	INITIAL RELEASE		
A		F185	PAGE 9: ADDED WET BULB TEMP. PAGE 29: ADDED DATE LABEL SHAPE, SIZE, MONTH AND YEAR. REMOVED REFERENCE TO FIGURE 4.3. PAGE 31: ADDED APPLE TO PART NUMBER 1.0 HIGH.	<i>2/2C</i>	<i>12/83</i>
A		F207	PRODUCTION RELEASE	<i>8/11/84</i>	<i>8/11/84</i>

SPECIFICATION FOR 3.5 INCH SINGLE SIDED DISK DRIVE

APPLE PART NUMBER 699-0285

SHEET 39 is E SIZE DRAWING

 <b>METRIC</b> <small>DIMENSIONS ARE IN MILLIMETERS</small> <small>TOLERANCES</small> X° ANGLES XX° <small>UNLESS OTHERWISE SPECIFIED</small>		 <b>apple computer inc.</b>	
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MATERIAL DRFT ENG APPV RELEASE DESIGNER	FINISH DRFT CK 10/83 GLC 11/83 11/83 ENG DIV MAC	SIZE A	DRAWING NUMBER 699-0285-A
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## 1.0 Description

This specification defines a single sided 3.5 inch Micro-Floppy disk Drive, Apple part number 699-0285.

## 2.0 Specification

The drive shall satisfy the following specifications when a diskette meeting the Apple disk specification, specification number 003-0001, is used.

### 2.1 Configuration

The drive consists of a read/write head, head positioning mechanism, disk motor, interface logic circuit, read/ write circuit, and auto eject, and uses a 3.5 inch microfloppy diskette, as shown in Figure 2.1. The drive itself shall meet UL 478 and CSA C22.2 No. 154-1983 requirements for safety.

### 2.2 Mechanical Dimensions

The mounting holes are shown in Figure 2.2, and the complete mechanical dimensions are shown in Apple drawing number 699-0285 page 39, which is an addendum to this specification available on request.

### 2.3 Performance

2.3.1 Capacity and Encoding Method - see Appendix B

#### 2.3.2 Transfer Rate

Detected flux transistions shall occur not less than 1.89 usec nor more than 6.36 usec apart.

#### 2.3.3 Access Time

- a. Track to track slew rate : 12 msec Max
- b. Track to track step settling time : 30 msec Max  
(These times are satisfied when the head is positioned and stable within 0.035 mm of its absolute position as defined in 2.11.)
- c. Speed group to speed group motor settling time : 150 msec Max
- d. Motor start time : 400 msec Max  
(These times are satisfied when the motor speed has settled to within +/- 1% of its final average rpm.)



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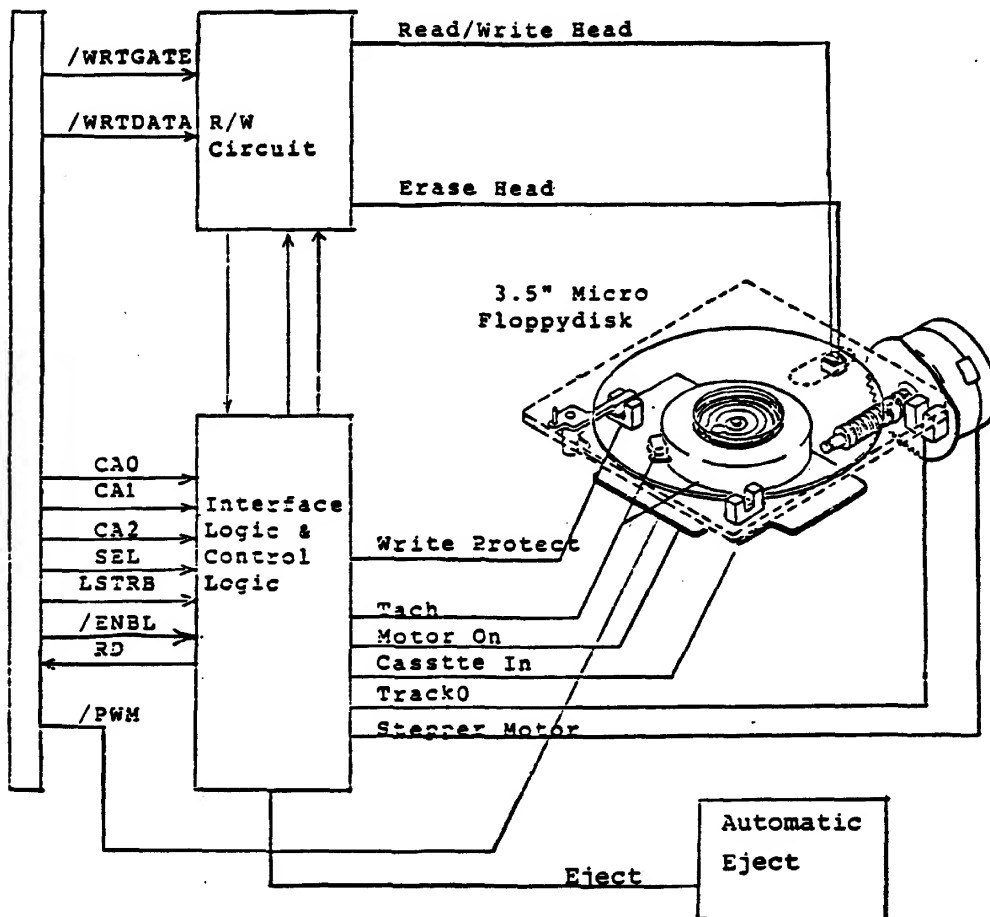


Figure 2.1 Configuration of Disk Drive



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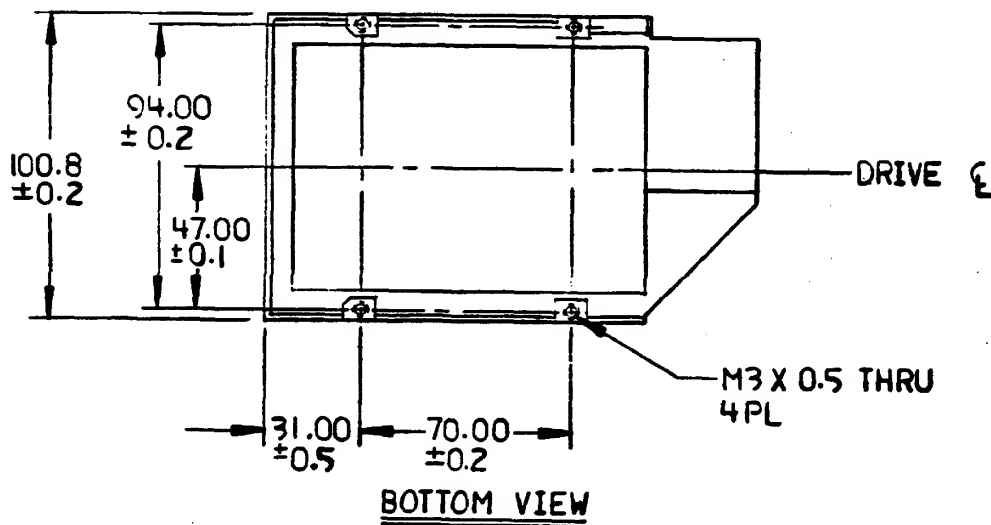
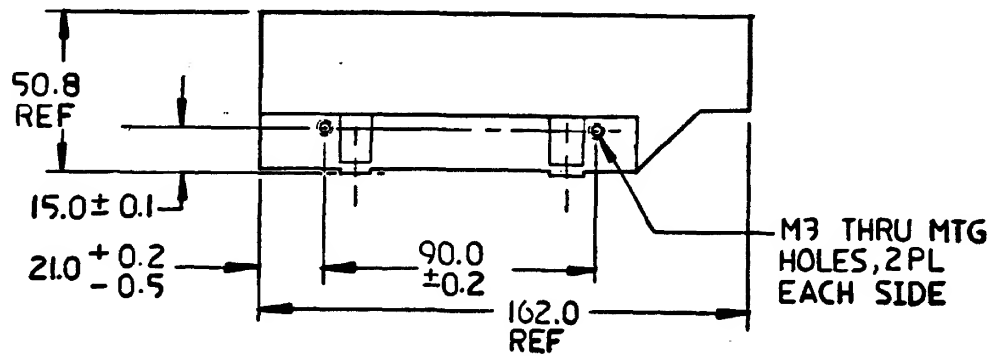


Figure 2.2 Mounting Hole Dimensions

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#### 2.3.4 Functional

##### a. Rotational Speed:

The motor speed is variable to allow recording to be done at fixed density as the head moves from the outer edge of the diskette toward the center. The speed is continuously variable from 390 to 605 rpm using a pulse width modulated signal input.

The detailed specifications on disk motor speed are given in 2.17.

##### b. Recording Density

The maximum recording density assumes all 2 usec transistions while the minumum density assumes all 6 usec transistions even though the format doesn't allow more than one 6 usec interval to be written at a time.

Maximum	: 8472 FCI
Minimum	: 2365 FCI

c. Track Density : 0.1875mm Track - Track

d. Tracks : 80

e. R/W Head : 1

#### 2.3.5 Weight: 750g Max

#### 2.4 Input Power Requirements

Voltage	Max. Ripple	Current
+12.0V +/-5%	0.1Vpp	Standby 0.15A (motor off) Average 0.3A (motor on) Peak 1.0A (stepping)
+5.0V +/-5%	0.1Vpp	0.5A maximum

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## 2.5 Environmental limits

### 2.5.1 Temperature

Operating : 5 C to 50 C (40 F to 122 F) ambient

Non-Operating: -40 C to 60 C (-40 F to 140 F)  
The temperature cycling shall not result in condensation.

### 2.5.2 Humidity

Operating : 20% to 80% relative humidity with a wet bulb temperature of 29 C (85 F), with no condensation.

5% to 90% relative humidity with a wet bulb temperature of 37.8 C (100 F) if the track alignment specification (Section 2.11) is relaxed to  $\pm 0.040$  mm from  $\pm 0.035$  mm, with no condensation.

Non-Operating: 5% to 95% relative humidity with no condensation.

### 2.5.3 Vibration

Operating : The unit shall perform read/write operation without errors with continuous vibration from 5 to 100 Hz at a maximum of 0.5G along each of the three mutually perpendicular axes.

Non-Operating: The unit shall be able to withstand continuous vibration from 5Hz to 300Hz with a maximum level of 2.0G along each of the three mutually perpendicular axes without any degradation of any characteristics below the performance specification.

### 2.5.4 Shock

Operating : The unit shall be able to withstand a 1.0G shock for 11 milliseconds with a 1/2 sine wave shape in each of the three mutually perpendicular axis while performing normal read/write functions without damage or any loss of data.

Non-Operating: The unit when unpacked shall withstand a shock of 60G on any of the three mutually perpendicular axis.



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## 2.6 Noise

Operating : Noise from the drive shall be less than 55 Dba at a point 50cm from the drive.

## 2.7 Orientation

The drive may be used in the three orientations shown in Figure 2.3.

## 2.8 Reliability

- a. Mean Time Between Failure (MTBF): 8000POH
- b. Mean Time to Repair (MTTR) : 30 minutes
- c. Preventive Maintenance (PM) : Not Required
- d. Component life : 5 years
- e. Error Rate

- 1. Soft Read : 1 per 10<sup>9</sup> bits read
- 2. Hard Read : 1 per 10<sup>12</sup> bits read
- 3. Seek Error : 1 per 10<sup>6</sup> seeks

## 2.9 Overwrite Characteristics

The residual level of 1F (125 KHz) measured as follows shall be greater than 30 db.

To measure, first record the 1F signal on TK0, then write over the track once with a 2F (250 KHz) signal, and measure the residual level of 1F at the read head.

Residual signal level ratio (db):

2F signal level (db) - residual level of 1F (db)



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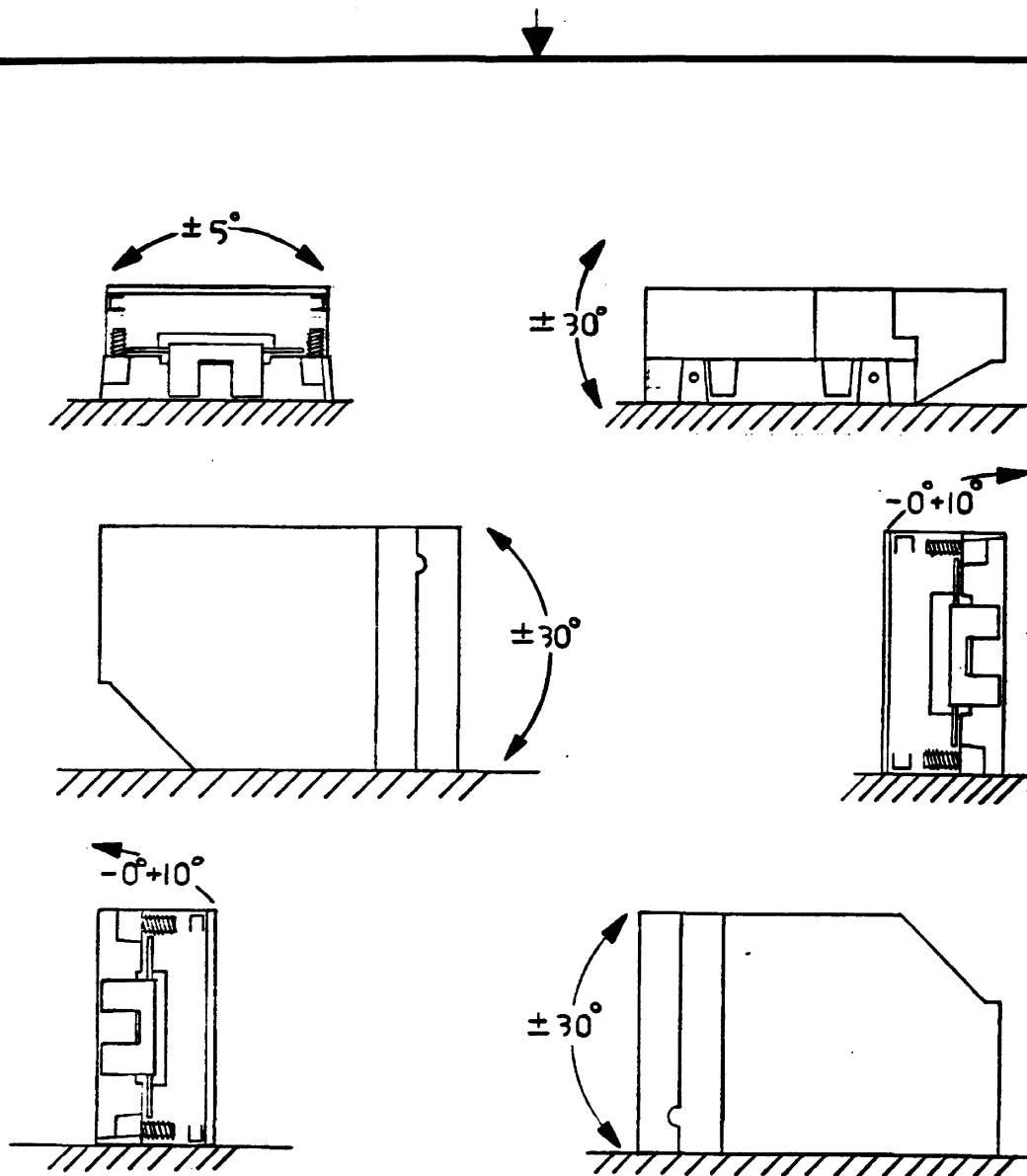


Figure 2.3 Allowable Orientations



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## 2.10 Time Margin

### 2.10.1 Definition of time margin

Time margin is measured using the Apple jitter generating fixture. This circuit jitters the read pulse coming from the drive under test randomly. The time margin is defined as the largest value of time that the read pulse can be jittered while still allowing the controller to read with fewer than one error in ten million bits read. The schematic of the jitter generator, Apple part number 890-2002, is shown in Appendix A.

The data read is comprised of a random pattern of flux changes including all legal combinations of 2, 4, & 6 usec periods between flux changes.

Track format and Sector format is defined in Appendix B.

### 2.10.2 Self read/write time margin

The self read/write time margin shall be: >300 nS

### 2.10.3 Off-track Time Margin

The time margin using a reference disk on which random data is written +0.035 mm and -0.035 mm off track shall be >300 ns.



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### 2.11 Alignment Accuracy

**Track position is defined by:**

$$RN = 39.5 - 0.1875 \times N$$

Where RN: Absolute track position from disk center  
N: Track number from 0 to 79

Alignment Accuracy at track 40 shall be:  $\pm 0.020$  mm

Alignment Accuracy at all other tracks shall be:  $\pm 0.035$  mm

### 2.12 Azimuth Angle

Azimuth Angle shall be;

Angle = arcsin (0.35 / (X - YN)) +/- 0 degrees 30'

where :  $X = 39.5$   
 $Y = 0.1875$   
 $N = \text{Track number (0 to 79)}$

Azimuth angle is defined in Figure 2.4.

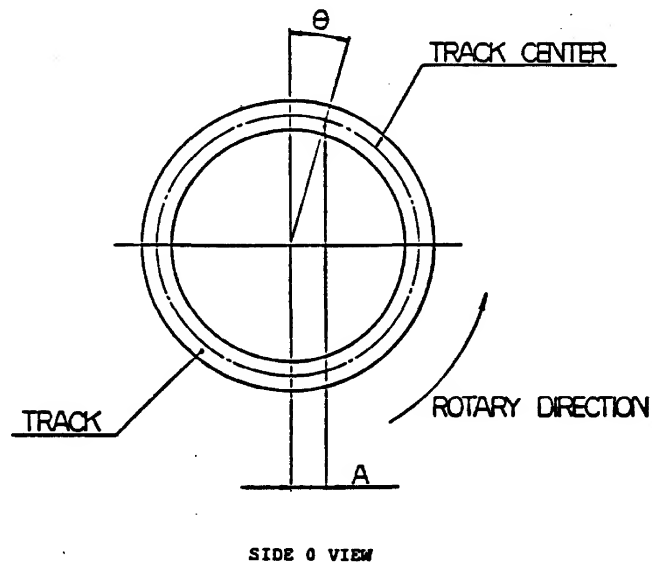


Figure 2.4 Azimuth Angle

### 2.13 Off Track Error Rate

- a. Using the plus-off-tracked disk on which random flux transistions are recorded off-track +35um from the reference position on all tracks, the drive shall meet the error rate specification.
- b. Using the minus-off-tracked disk on which random flux transistions recorded off-track -35um from the reference position on all tracks, the drive shall meet the error rate specification.

### 2.14 Temperature Inside Drive

The temperature rise above ambient at the disk surface inside of the drive shall not exceed 10 degrees C when the drive is used at 50% duty cycle Random Seek with random reads and writes. The drive shall be set in free air at an ambient temperature of 50 degrees C maximum.

### 2.15 Head Life

Head life shall be more than (20,000,000) passes. Measured as follows:

- a. Using a new disk, which is used as the reference disk for signal level, and a new drive, move the head to Track 35, then record 2F signal. Measure the output signal level (Lr).
- b. Insert another new disk into the drive. Move the head from Track 0 to Track 79 and back to Track 0 about 3,000,000 passes.
- c. Change the disk to another new disk.
- d. Repeat (b) and (c) until total number of passes is 20,000,000.
- e. Change the disk to the reference level disk used in (a). Move the head to Track 35, measure the output signal level (Lx).
- f. The ratio of Lx over Lr shall be > 80% as follows:

$$\frac{Lx}{Lr} \times 100\% > 80\%$$



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## 2.16 Media Wear

Write the 2F signal on every track of a new disk, and read the output level of all of the tracks and record. After 3,000,000 read passes on track 35, the output level of all tracks should be 80% minimum of the originally measured value of each track.

## 2.17 Disk Motor

The disk motor speed shall be controlled by a PWM signal from the host computer. The specifications of the disk motor are as follows:

### 2.17.1 Speed Control Range

- a. Speed at 9.4% duty cycle of PWM with the diskette in place and head at TK0 (measured at 25 +/- 3 degrees C) shall be:

$$305 < V < 380\text{rpm}$$

low

- b. Speed at 91% duty cycle of PWM with diskette in place and head at TK79 (measured at 25 +/- 3 degrees C) shall be:

$$625 < V < 780\text{rpm}$$

high

- c. Over the full environmental range as specified in Section 2.5, and with a diskette in place the following speeds must be guaranteed including all jitter and drift effects:

With the head positioned at TK0 and the PWM set to 9.4%, the motor speed must be less than 390 rpm.

With the head positioned at TK79 and the PWM set to 91%, the motor speed must be greater than 605 rpm.

### 2.17.2 Linearity

Non-linearity of the disk motor speed shall be less than 2.0%.

Linearity is defined as,

$$\text{Linearity} = \left| \frac{V_x - V_r}{V_r} \right| \times 100\%$$

where :

$$V_r = \frac{(V_a - V_b)}{81.6} (x - 9.4) + V_b$$

Vx : Measured speed at a PWM duty cycle of x %.

Va : Measured speed at a PWM duty cycle of 91%.

Vb : Measured speed at a PWM duty cycle of 9.4%.



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### 2.17.3 Jitter

Jitter of the disk motor speed shall be less than 1.8% peak - peak when measured at a motor speed of between 390 and 605 RPM. Jitter is defined as:

$$\text{Jitter} = \frac{4 S_x}{S_m} \times 100\%$$

where :  $S_x$  is the standard deviation of the TACH pulse period sampled randomly 100 points and  $S_m$  is the mean of Tach pulse period.

### 2.17.4 Thermal drift

Thermal drift of disk motor speed for any speed between 390 and 605 rpm shall be less than 3%. The definition of the thermal drift:

$$\text{Thermal drift} = \left| \frac{V_x - V_r}{V_r} \right| \times 100\%$$

where :  $V_r$  : Disk motor speed at 25 C ambient temperature.

$V_x$  : Disk motor speed between 5 C to 50 C ambient temperature.

### 2.17.5 Initial drift

Initial drift of disk motor speed shall be less than 1.0%. Initial drift is defined as:

$$\text{Initial drift} = \left| \frac{V_x - V_r}{V_r} \right| \times 100\%$$

where :  $V_r$  : Disk motor speed at 1 sec after disk motor is turned on.

$V_x$  : Disk motor speed at 120 sec after disk motor is turned on.

### 2.17.6 Speed - Torque characteristics

The change of speed with torque is:

Ratio of speed/torque : -0.25% /gram cm



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## 2.18 Eject Mechanism

### 2.18.1 Eject Timing

From the leading edge of the eject signal which is  $750 \pm 25$  milliseconds in duration, the total eject time shall be less than 1.5 seconds. Note that the "cassette in" signal is not guaranteed to indicate no cassette in place until the eject operation is complete.

### 2.18.2 Eject Mechanism Life

The eject mechanism shall be capable of at least 20,000 disk insertions and ejections using the auto eject mechanism without degradation of specifications or failure. Both insertion and ejection shall be smooth and quiet.

### 2.18.3 Manual Eject

A mechanism shall be provided which allows manual eject of the diskette. The maximum pressure necessary to eject the diskette using this mechanism shall be 1.3 Kg.



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### 3.0 Interface

#### 3.1 General Description

The interface between the host system and the drive consists of 6 input signals (SEL, CA2, CA1, CA0, /ENBL, and LSTRB) and one output signal (RD). For any communication with the drive, the /ENBL line must be low.

##### 3.1.1 Reading Status or Data from Drive.

The host system can read the status of the drive or data on the disk using the RD line by setting the CA0, CA1, CA2 and SEL signals as shown in the table (the RD line is a tristate line which is in the high impedance state unless /ENBL is low).

SEL	CA2	CA1	CA0	Output signal on RD line
0	0	0	0	/DIRTN
0	0	0	1	/STEP
0	0	1	0	/MOTORON
0	0	1	1	(EJECT)
0	1	0	0	RDDATA (Head0)
0	1	1	0	SIDES
0	1	1	1	/DRVIN
1	0	0	0	/CSTIN
1	0	0	1	/WRTROT
1	0	1	0	/TKO
1	0	1	1	/TACH
1	1	0	0	RDDATA (Head1)
1	1	1	0	Reserved
1	1	1	1	Reserved

##### 3.1.2 Sending Control Commands to Drive.

The host system can send four commands: /DIRTN, /STEP, /MOTORON and EJECT. To send one of the control commands to the drive, set CA2 to the value (a zero or a one) to which the host system wishes the command to be set, and then set CA0, CA1 and SEL to the value which selects the desired command. Finally, bring LSTRB first high and then low.

Note 1: EJECT is an unlatched output only: EJECT is a signal which cannot be read (it always reads the value one). To eject a disk, set SEL, CA2, CA1 and CA0 as 0111, then hold LSTRB high for 750 msec.

Note 2: CA0, CA1, CA2 and SEL must not change value while LSTRB is high and CA0 and CA1 must be returned to a one level before changing SEL.



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### 3.2 Signal Descriptions

#### 3.2.1 /CSTIN

This signal goes to a zero only when a disk is in the drive.

#### 3.2.2 /WRTPRT

This signal goes to a zero only when a write-protected disk is in the drive, or when no disk is in the drive.

#### 3.2.3 /TKO

This signal goes to a zero only when the head is located at track 0. From the time the /STEP signal is set to a zero, a delay of 12msec is required before TKO is valid.

#### 3.2.4 /TACH

This signal is used to monitor the disk motor speed. /TACH signal specification is as follows:

Number of pulses per rotation : 60  
Duty cycle : 50% +/- 10%  
Accuracy of pulse period : +/- 0.2%

#### 3.2.5 /DIRTN

This signal sets the direction of head motion for stepping from one track to another. A zero sets the direction towards the center of the disk. A one sets the direction towards the outer edge of the disk. When the drive is disabled (/ENBL high), /DIRTN is set to a zero.

#### 3.2.6 /STEP

At falling edge of this signal, the head starts to move to the adjacent track. When the step sequence is complete, /STEP is set to a one by the drive. The direction is determined by /DIRTN. When the drive is disabled (/ENBL high), /STEP is set to a one.

#### 3.2.7 /MOTORON

When this signal is set low, the disk motor is turned on if a disk is in the drive. When the drive is disabled (/ENBL high), /MOTORON is set to a one.



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### 3.2.8 EJECT

Setting EJECT to a one causes the disk to be ejected from the drive. The EJECT must be a one for 750 msec +/-25 msec to eject a disk. When the drive is disabled (/ENBL high), the EJECT is set to a zero.

### 3.2.9 SIDES

This status bit is read as a zero if the drive is single-sided, or a one if the drive is double-sided.

### 3.2.10 /DRVIN

This status bit is read as a zero only if the selected drive is actually connected to the host system.

### 3.2.11 RDDATA

RDDATA is the actual data read from the disk.

### 3.2.12 /PWM

The /PWM signal is used by the host computer to adjust the speed of the drive motor. This TTL level signal transmits timing information in the form of a fixed pulse rate of from 20 KHz to 40 KHz. The duty cycle of each pulse is defined as the percentage of time the signal is at a logic zero level. The disk motor speed control is specified to operate at the correct speed for duty cycles between 10% and 90%. One implementation of the speed control uses a PWM rate of 22 KHz, and gains extra resolution by "dithering" the pulse duty cycle such that each set of 10 successive pulses varies in duty cycle. This method increases the resolution by a factor of 10 but also results in decreasing the effective frequency of the control signal to 2.2 KHz.

### 3.2.13 CA0, CA1, CA2, SEL

These signals are used to multiplex inputs from the drive to the RD line during a read operation. During a command write operation these signals select addressable latches in the drive (except for EJECT). CA2 serves the special purpose of selecting a one or a zero to be set into the addressable latches during a write. SEL is used as "Head Select" for a double sided drive during a read.

#### 3.2.14 /ENBL

This line enables all communication with the drive. When /ENBL is high (drive disabled), the RD output goes into a high impedance state, and the control latches in the drive are preset to their inactive states..

#### 3.2.15 LSTRB

This line is used to send a command to the drive. After setting CA0, CA1, CA2 and SEL to the desired state, LSTRB is brought first high and then low.

#### 3.2.16 RD

This line is the only output line from the drive. It is multiplexed by the control lines and allows the host to read disk status information as well as data.

#### 3.2.17 WRTDATA

This line is used for data that is to be written on the disk. The magnetized pattern on the disk is same as the level of WRTDATA. Each change in the level of WRTDATA causes a flux transistion to be written on the disk. WRTDATA is allowed to record on the disk only when /WRTGATE is a zero.

#### 3.2.18 /WRTGATE

This signal enables data to be written on the disk and turns on the erase head.



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### 3.3 DC Characteristics of Interface Signals

#### 3.3.1 Output Drive

<u>Name</u>	<u>Output Current</u> (milliamps)		<u>Output Voltage</u> (volts)	
	<u>IOH</u>	<u>IOL</u>	<u>VOH</u>	<u>VOL</u>
RD*	-1.0	6.5	2.4	0.5

#### 3.3.2 Input Loading

<u>Name</u>	<u>Input Current</u> (milliamps)		<u>Input Voltage threshold</u> (volts)	
	VIN=2.4V	VIN=0.4V	<u>VIH</u>	<u>VIL</u>
	<u>IIH</u>	<u>IIL</u>		
WRTDATA*, /WRTGATE*	-0.9	-1.5	2.0	0.8
CA0-CA2, LSTRB, SEL	0.1	-0.25	2.0	0.8
/ENBL	0.125	-0.75	2.2	0.8
/PWM	0.01	-0.04	2.0	0.8

\*These signal lines include a 3.3K pull-up resistor to +5v.

### 3.4 Timing Requirements

The following sections contain timing diagrams which show the relationship between the input and output signals.



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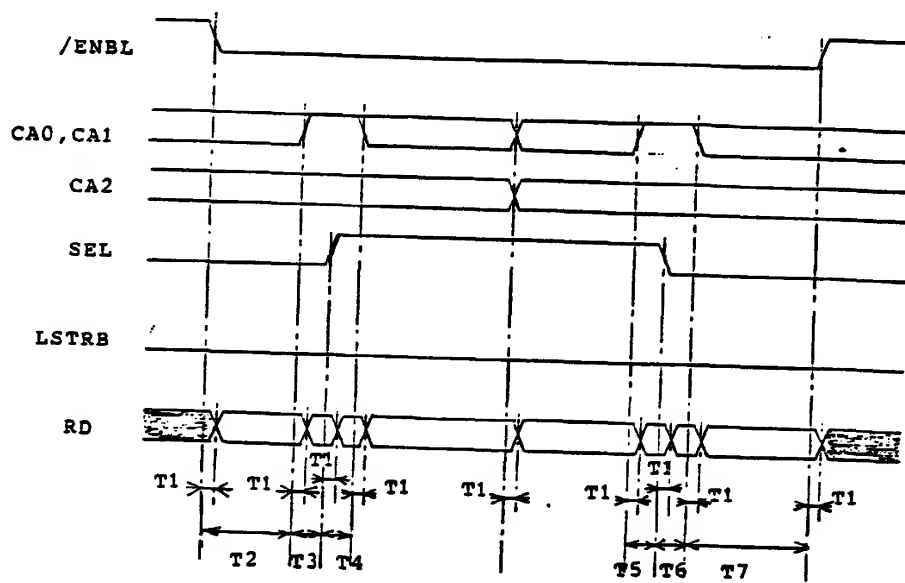
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### 3.4.1 Reading one of the status signals



T1 : 0.5 us Max  
 T2 : 0.5 us Min  
 T3 : 0.5 us Min  
 T4 : 0.5 us Min  
 T5 : 0.5 us Min  
 T6 : 0.5 us Min  
 T7 : 1 us Min

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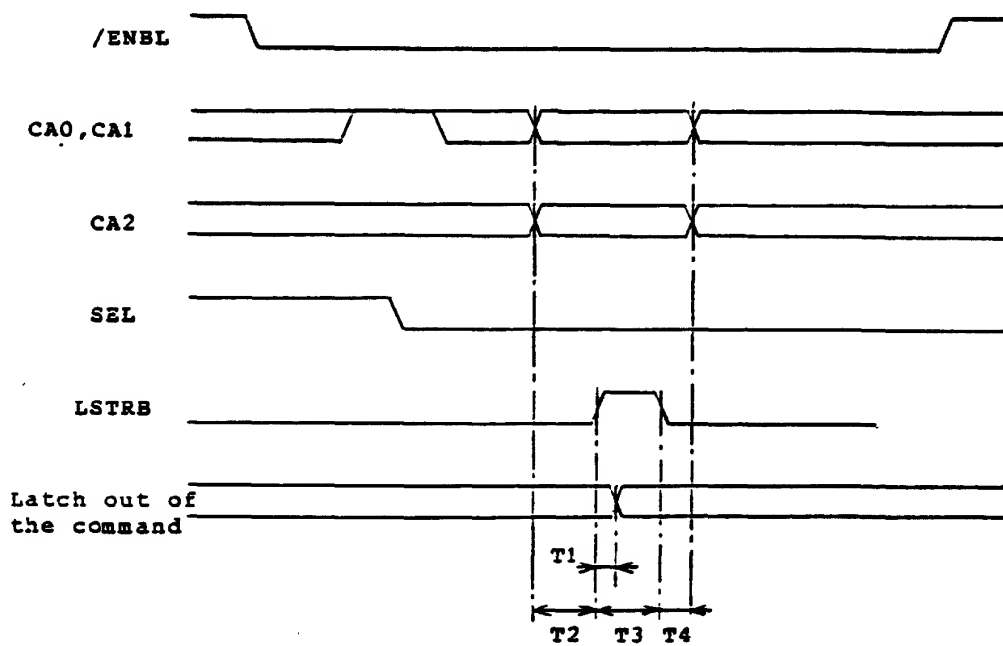
SIZE  
A

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### 3.4.2 Sending one of the control commands



T1 : 1 us  
 T2 : 0.5 us  
 T3 : 1 us Min except for EJECT  
           0.75 s for EJECT  
 T4 : 0.5 us

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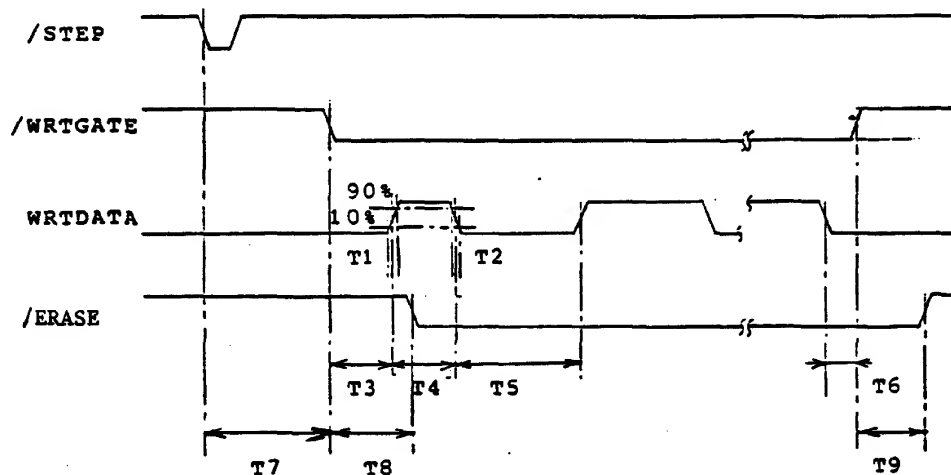
DRAWING NUMBER  
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SCALE:

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### 3.4.3 /WRTGATE, WRTDATA and /ERASE Timing



T1	:	100 ns Max
T2	:	100 ns Max
T3	:	1.8 us
T4	:	2 us +/- 0.05 us for 2 usec period*
	:	4 us +/- 0.05 us for 4 usec period*
	:	6 us +/- 0.05 us for 6 usec period*
T5	:	2 us +/- 0.05 us for 2 usec period*
	:	4 us +/- 0.05 us for 4 usec period*
	:	6 us +/- 0.05 us for 6 usec period*
T6	:	2us
T7	:	12 ms + 30 ms Min
T8	:	250 us +/- 6 us
T9	:	884 us +/- 5 us

\*These numbers will be different if the system clock frequency is different, however, since the disk controller controls both read and write frequency, no decrease in time margin is experienced due to this effect. For disks recorded on different systems to be interchangeable, the data density on the disk must be the same.



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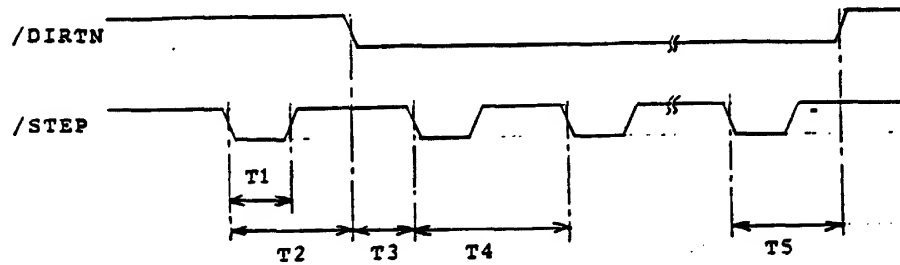
SIZE  
A

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699-0285-A

SCALE:

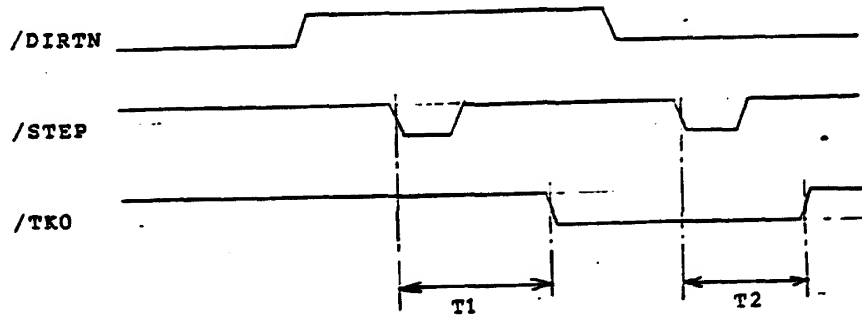
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#### 3.4.4 /DIRTN and /STEP Timing



T1 : 10 us Min 12 ms Max  
 T2 : 10 ms Min  
 T3 : 2 us Min  
 T4 : 12 ms Min  
 T5 : 11 us Min

#### 3.4.5 /TKO Timing



T1 : 12 ms Max  
 T2 : 12 ms Max

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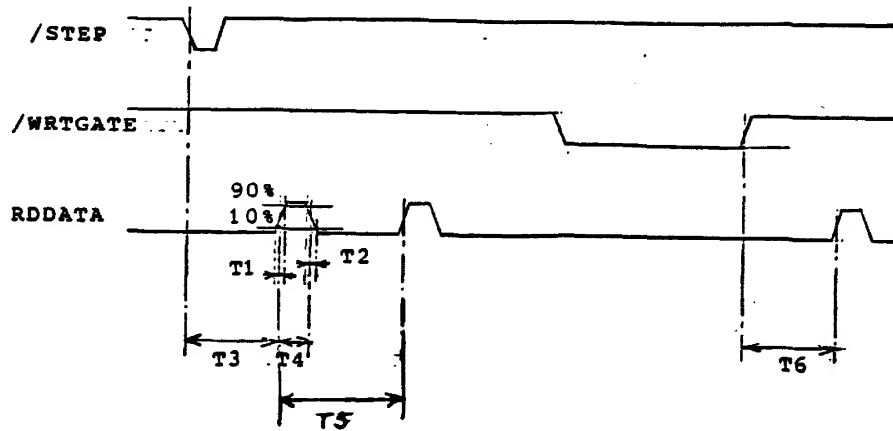
DRAWING NUMBER

699-0285-A

SCALE:

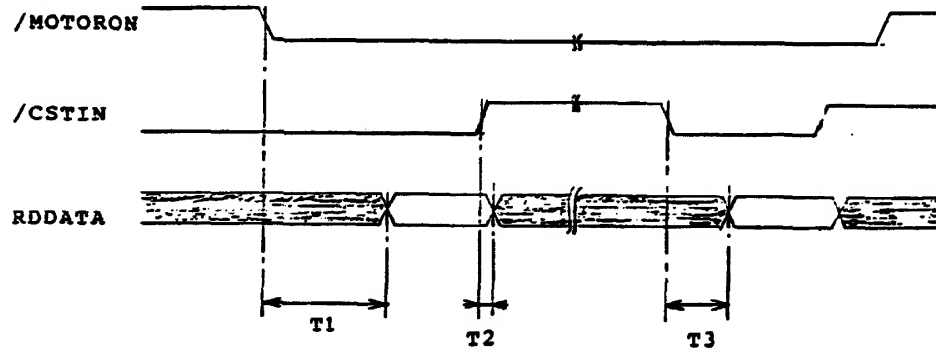
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### 3.4.6 RDDATA VALID TIMING - CONDITION 1



- T1 : 100 ns Max
- T2 : 100 ns Max
- T3 : 12 ms STEP + 30 ms HEAD SETTling
- T4 : 400 ns Min 800 ns Max
- T5 : 2 us, 4 us, or 6 us
- T6 : 10 us (data error may occur when ERASE goes off)

### 3.4.7 RDDATA VALID TIMING - CONDITION 2



- T1 : 400 ms Max
- T2 : No Requirement
- T3 : 1 second Max

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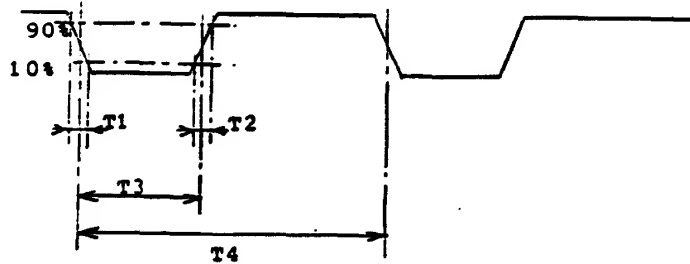
DRAWING NUMBER

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### 3.4.8 /PWM WAVEFORM



T1 : 50 ns  
T2 : 50 ns  
T3 : 10% to 90% of T4  
T4 : 25 us to 50 us

### 3.5 Power On and Power Off Requirements

#### 3.5.1 Data Protection

There shall be no damage to recorded data on the disk during either a power on or power off operation as long as the disk is not in the middle of a write when power is turned off.

#### 3.5.2 Power Supply Sequencing

No special power supply sequencing shall be required by the disk as long as both the +5 volt and +12 volt power supplies have a monotonic rise time of less than 100 milliseconds. That is there shall be no ringing on the supplies during turn on or turn off which causes them to rise above and then fall below their specified voltage. Some ringing is tolerable as long as it doesn't cause the voltage to exceed or fall below the specified limits (+/-5%).

At turn off, both supplies must fall monotonically to zero volts, however, there are no sequencing or timing requirements.



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### 3.5.3 Head Position Initialization

At power on, the head shall be automatically accessed to track 0.

### 3.6 Interface Connector and Pin Assignment

The interface connector shall be a 20 pin connector, 3M J3428-5202 or equivalent. The pinouts are as follows:

<u>Pin number</u>	<u>Signal Name</u>	<u>Pin Number</u>	<u>Signal Name</u>
1	GND	2	CA0
3	GND	4	CA1
5	GND	6	CA2
7	GND	8	LSTRB
9	N/C	10	/WRTGATE
11	+5V	12	SEL
13	+12V	14	/ENBL
15	+12V	16	RD
17	+12V	18	WRTDATA
19	+12V	20	/PWM

### 4.0 Labelling

The drive shall have two labels attached when it is shipped to Apple.

#### 4.1 Label Position

The serial number label shall be attached to the right side, and the date label to the left side of the chassis as shown in Figure 4.1.

#### 4.2 Label Contents

The shape and contents of the serial number label shall be as shown in Figure 4.2. The date label shape and size may be picked by the drive manufacturer, but must include the month and year of manufacture and be clearly legible.



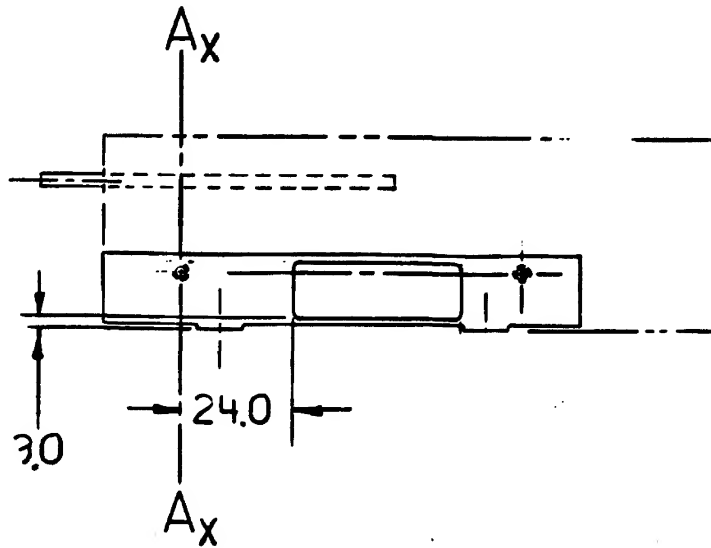
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SCALE : NONE  
TOL. : XX.X  $\pm$  0.4

Figure 4.1 Label Position

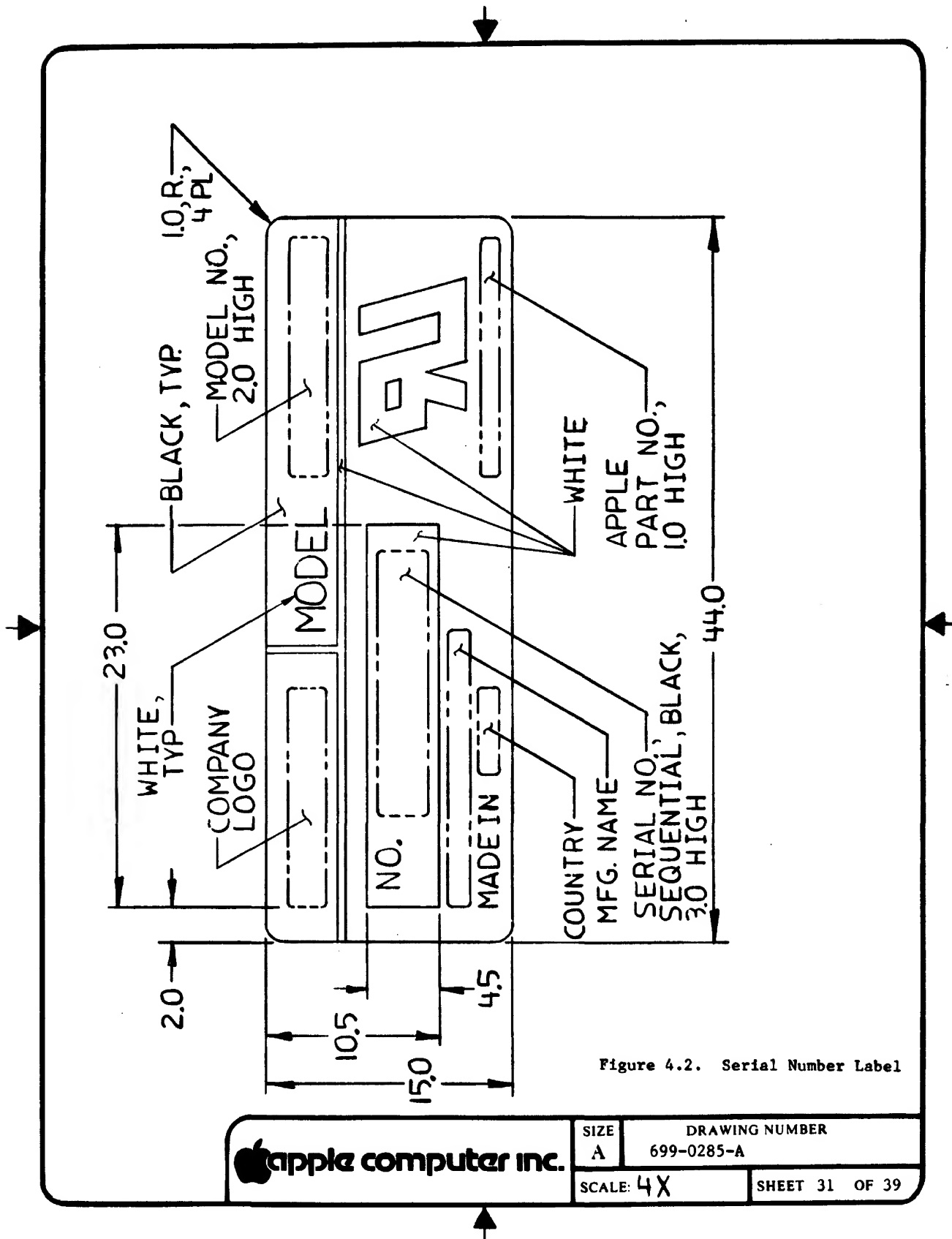
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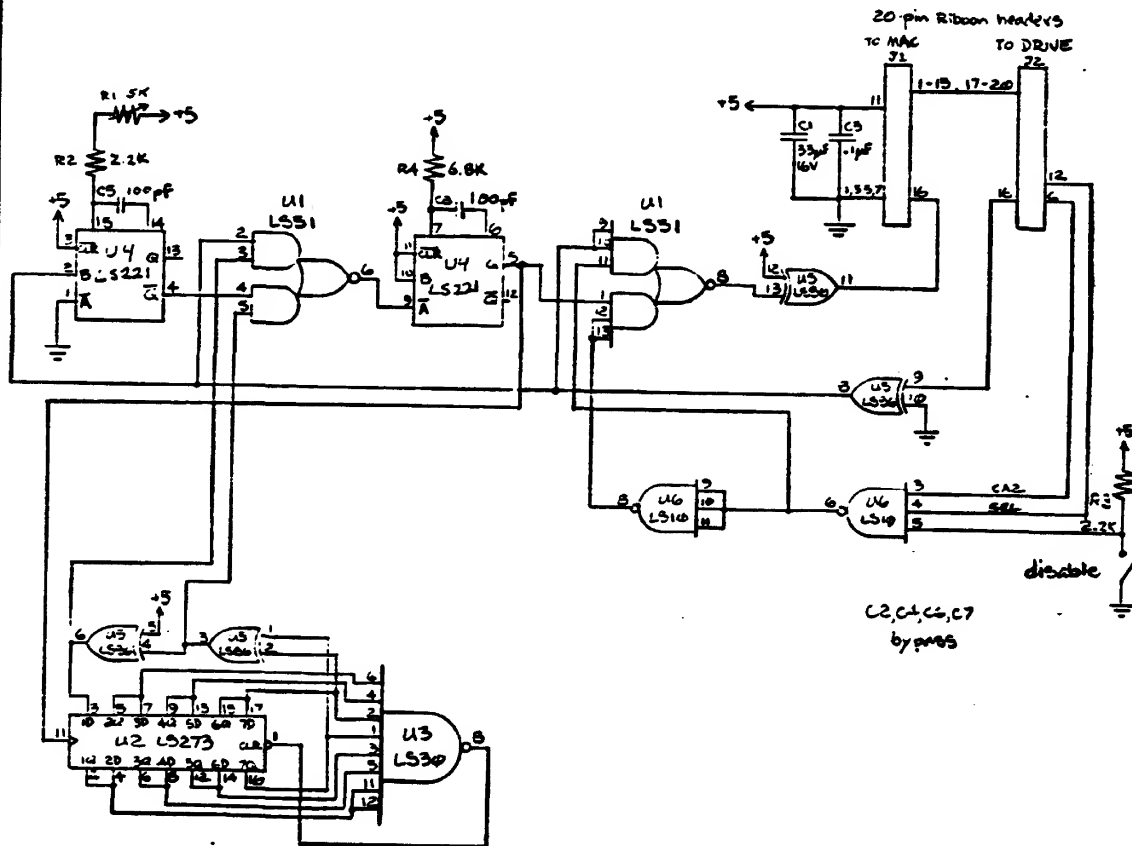
SIZE  
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SCALE: 4X

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# Appendix A. Jitter Generator Schematic



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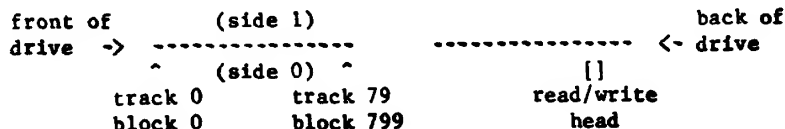
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## Appendix B. Sector Format

This document describes the sector format used for single-sided 3-1/2 inch diskettes; provision is made for eventual expansion to double-sided diskettes.

The current drive has a single read/write head located on the bottom of the drive at the back (the diagram below shows a side-view of a drive, the dotted line representing a diskette):



There are 80 tracks on the drive, numbered from track 0 (the outermost track) through track 79 (the innermost track). The single side is side 0: the top side, side 1, will be used on future double-sided disk drives.

The number of sectors per track varies from 12 on the outside tracks to 8 on the inside tracks as shown in the following table. Speed 1 represents a data transfer rate of 489.6 K bits/sec. Speed 2 is for 500 K bits/sec. The different speeds record the data at a fixed density and allow the diskettes to be interchanged.

Track	Speed Group	Sectors/Track	Speed 1	Speed 2
0 - 15	1	12	394	402
16 - 31	2	11	429	438
32 - 47	3	10	472	482
48 - 63	4	9	525	536
64 - 79	5	8	590	603

This format is derived by limiting the sectors per track for the single-sided drive according to the smaller radius of the opposite-side track of the future double-sided drive. This format yields a total of 800 sectors or blocks. Block numbering goes from 0 to 799: block 0 is sector 0 on track 0 and block 799 is sector 7 on track 79 (sectors are numbered from 0). Future double-sided disks will have an additional 800 blocks on side 1; these blocks will be interleaved with side 0 blocks in a cylinder fashion (blocks 0-11 will be on side 0, track 0, blocks 12-23 will be on side 1, track 0, etc.).

Sectors are typically interleaved 2:1 because of the write recovery time. As an example, the sector sequencing for 2:1 interleave is:

speed group 1: 0-6-1-7-2-8-3-9-4-10-5-11  
speed group 2: 0-6-1-7-2-8-3-9-4-10-5  
speed group 3: 0-5-1-6-2-7-3-8-4-9  
speed group 4: 0-5-1-6-2-7-3-8-4  
speed group 5: 0-4-1-5-2-6-3-7



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## Sector Format

A sector can be divided into four major sections. These are the header sync field, the header field, the data sync field, and the data field. These fields combined add up to 733.5 code bytes minimum.

### Header Sync Field (6.25 bytes + sync overhead)

5 bit slip FFs minimum (FF,3F,CF,F3,FC,FF)

The header sync field contains a pattern of ones and zeroes that synchronizes the hardware state machine with the data on the disk. The header sync and header fields are written only when the diskette is formatted. The formatter should make this field as large as possible since this field buffers expansion of the previous sector's data field due to speed variation of the drive.

### Header Field (11 bytes)

D5 AA 96 Trk Sect Side Fmt ChkSum DE AA off

The header field identifies the sector. The sub-fields are:

D5	address marks: this identifies the field as a header field.
AA	encoded low 6 bits of track number
96	encoded sector number
Trk	encoded high 2 bits of track number and side bit:
Sect	decoded bit 5 = 0 for side 0, 1 for side 1
Side	decoded bit 0 is the high-order bit of the track number
	decoded bits 1-4 are reserved and should be 0
Format	encoded format specification:
	decoded bit 5 = 0 for single-sided formats
	decoded bits 0-4 define the format interleave:
	standard 2:1 interleave formats have a 2 in this field
Checksum	checksum formed by exclusive 'or'ing the track, sector, side, and format fields
DE	bit slip marks: this identifies the end of the field
AA	pad byte where the write electronics were turned off
off	

### Data Sync Field (6.25 bytes)

5 bit slip FFs (FF,3F,CF,F3,FC,FF)

The data sync field contains a pattern of ones and zeroes that synchronizes the state machine with the data on the disk. This field is written whenever the data field is written.



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D5 AA AD Sect <encoded data> ChkSum DE AA off

D5 AA AD	data marks: this identifies the field as a data field.
Sector	encoded sector number
encoded data	524 data bytes encoded into 699 code bytes; the first 12 data bytes are typically used as a sector tag by the operating system, and the remaining 512 bytes for actual data
Checksum	a 24-bit checksum encoded into 4 code bytes (see below)
DE AA	bit slip marks: this identifies the end of the field
off	pad byte where the write electronics were turned off

A sector is composed of 524 user data bytes and a 3 byte checksum. These are translated into 6 bit nibbles that are used to look up GCR codewords to be written to the disk. The data is encoded as follows. CSUMA, CSUMB, CSUMC are registers used for accumulating the checksum. BYTEA, BYTEB, BYTEC contain three bytes from the data buffer. GCR is the table of GCR codewords.

- ```

+-----+-----+
|       |       | Note carry out of CSUMC
+-----+-----+
+CSUMC <--CSUMB <--CSUMA <--+ is from rotate.

```

**Figure showing carry propagation**



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GCR Codeword Table (used to convert nibbles to GCR codewords)

|     |                         |
|-----|-------------------------|
| 0:  | 96,97,9A,9B,9D,9E,9F,A6 |
| 8:  | A7,AB,AC,AD,AE,AF,B2,B3 |
| 10: | B4,B5,B6,B7,B9,BA,BB,BC |
| 18: | BD,BE,BF,CB,CD,CE,CF,D3 |
| 20: | D6,D7,D9,DA,DB,DC,DD,DE |
| 28: | DF,E5,E6,E7,E9,EA,EB,EC |
| 30: | ED,EE,EF,F2,F3,F4,F5,F6 |
| 38: | F7,F9,FA,FB,FC,FD,FE,FF |

Speed Control

Disk speed is controlled via a PWM signal from the host computer. The duty cycle of this signal is set by software in the host computer; the appropriate value is determined by measuring the length of pulses on the tach sense line from the disk drive. The disk speed should be checked when a diskette is first inserted and periodically thereafter to allow adjustment for thermal drifting of disk speed. The speed should also be checked at the position on the diskette which corresponds to the actual speed group to compensate for torque loading of the motor.

Disk Storage Calculations

The next page shows how the track classes and speeds were determined. The following formulas were used:

track density: 135.4666 tracks/inch  
 0.1875 mm track to track  
 track 0 radius: 39.5 mm  
 max data density: 8750 fci = 344.4882 fcm  
 sync overhead: 6%  
 bytes/block 733.5  
 data speed: 500 kbits/sec

bytes:  $(733.5 * \text{blocks}) * 1.06$   
 rpm:  $60 \text{ sec/min} * 500\text{kbits/sec} / (\text{bytes} * 8\text{bits/byte})$   
 fci:  $\text{bytes} * 8\text{bits/byte} / (2 * \pi * \text{Radius in inches})$

The actual RPM values for Macintosh are adjusted for a bit rate of 489.6 kbits/sec and are slightly lower (e.g., 394 rpm instead of 402 rpm on the outside tracks).



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| TRACK | RADIUS<br>(side0) | RADIUS<br>(side1) | BLOCKS | BYTES   | RPM      | FCI<br>(side0) | FCI<br>(side1) |
|-------|-------------------|-------------------|--------|---------|----------|----------------|----------------|
| 0     | 39.5              | 38                | 12     | 9330.12 | 401.9241 | 7638.955       | 7940.493       |
| 1     | 39.3125           | 37.8125           | 12     | 9330.12 | 401.9241 | 7675.389       | 7979.867       |
| 2     | 39.125            | 37.625            | 12     | 9330.12 | 401.9241 | 7712.172       | 8019.634       |
| 3     | 38.9375           | 37.4375           | 12     | 9330.12 | 401.9241 | 7749.309       | 8059.799       |
| 4     | 38.75             | 37.25             | 12     | 9330.12 | 401.9241 | 7786.806       | 8100.369       |
| 5     | 38.5625           | 37.0625           | 12     | 9330.12 | 401.9241 | 7824.667       | 8141.349       |
| 6     | 38.375            | 36.875            | 12     | 9330.12 | 401.9241 | 7862.899       | 8182.745       |
| 7     | 38.1875           | 36.6875           | 12     | 9330.12 | 401.9241 | 7901.505       | 8224.565       |
| 8     | 38                | 36.5              | 12     | 9330.12 | 401.9241 | 7940.493       | 8266.815       |
| 9     | 37.8125           | 36.3125           | 12     | 9330.12 | 401.9241 | 7979.867       | 8309.500       |
| 10    | 37.625            | 36.125            | 12     | 9330.12 | 401.9241 | 8019.634       | 8352.629       |
| 11    | 37.4375           | 35.9375           | 12     | 9330.12 | 401.9241 | 8059.799       | 8396.208       |
| 12    | 37.25             | 35.75             | 12     | 9330.12 | 401.9241 | 8100.369       | 8440.244       |
| 13    | 37.0625           | 35.5625           | 12     | 9330.12 | 401.9241 | 8141.349       | 8484.745       |
| 14    | 36.875            | 35.375            | 12     | 9330.12 | 401.9241 | 8182.745       | 8529.717       |
| 15    | 36.6875           | 35.1875           | 12     | 9330.12 | 401.9241 | 8224.565       | 8575.168       |
| 16    | 36.5              | 35                | 11     | 8552.61 | 438.4626 | 7577.913       | 7902.681       |
| 17    | 36.3125           | 34.8125           | 11     | 8552.61 | 438.4626 | 7617.042       | 7945.245       |
| 18    | 36.125            | 34.625            | 11     | 8552.61 | 438.4626 | 7656.577       | 7988.270       |
| 19    | 35.9375           | 34.4375           | 11     | 8552.61 | 438.4626 | 7696.524       | 8031.763       |
| 20    | 35.75             | 34.25             | 11     | 8552.61 | 438.4626 | 7736.891       | 8075.733       |
| 21    | 35.5625           | 34.0625           | 11     | 8552.61 | 438.4626 | 7777.683       | 8120.186       |
| 22    | 35.375            | 33.875            | 11     | 8552.61 | 438.4626 | 7818.907       | 8165.132       |
| 23    | 35.1875           | 33.6875           | 11     | 8552.61 | 438.4626 | 7860.571       | 8210.578       |
| 24    | 35                | 33.5              | 11     | 8552.61 | 438.4626 | 7902.681       | 8256.533       |
| 25    | 34.8125           | 33.3125           | 11     | 8552.61 | 438.4626 | 7945.245       | 8303.005       |
| 26    | 34.625            | 33.125            | 11     | 8552.61 | 438.4626 | 7988.270       | 8350.003       |
| 27    | 34.4375           | 32.9375           | 11     | 8552.61 | 438.4626 | 8031.763       | 8397.536       |
| 28    | 34.25             | 32.75             | 11     | 8552.61 | 438.4626 | 8075.733       | 8445.613       |
| 29    | 34.0625           | 32.5625           | 11     | 8552.61 | 438.4626 | 8120.186       | 8494.245       |
| 30    | 33.875            | 32.375            | 11     | 8552.61 | 438.4626 | 8165.132       | 8543.439       |
| 31    | 33.6875           | 32.1875           | 11     | 8552.61 | 438.4626 | 8210.578       | 8593.207       |
| 32    | 33.5              | 32                | 10     | 7775.1  | 482.3089 | 7505.939       | 7857.780       |
| 33    | 33.3125           | 31.8125           | 10     | 7775.1  | 482.3089 | 7548.186       | 7904.093       |
| 34    | 33.125            | 31.625            | 10     | 7775.1  | 482.3089 | 7590.912       | 7950.955       |
| 35    | 32.9375           | 31.4375           | 10     | 7775.1  | 482.3089 | 7634.124       | 7998.376       |
| 36    | 32.75             | 31.25             | 10     | 7775.1  | 482.3089 | 7677.830       | 8046.366       |
| 37    | 32.5625           | 31.0625           | 10     | 7775.1  | 482.3089 | 7722.041       | 8094.936       |
| 38    | 32.375            | 30.875            | 10     | 7775.1  | 482.3089 | 7766.763       | 8144.095       |
| 39    | 32.1875           | 30.6875           | 10     | 7775.1  | 482.3089 | 7812.006       | 8193.856       |
| 40    | 32                | 30.5              | 10     | 7775.1  | 482.3089 | 7857.780       | 8244.228       |
| 41    | 31.8125           | 30.3125           | 10     | 7775.1  | 482.3089 | 7904.093       | 8295.223       |
| 42    | 31.625            | 30.125            | 10     | 7775.1  | 482.3089 | 7950.955       | 8346.853       |
| 43    | 31.4375           | 29.9375           | 10     | 7775.1  | 482.3089 | 7998.376       | 8399.130       |
| 44    | 31.25             | 29.75             | 10     | 7775.1  | 482.3089 | 8046.366       | 8452.065       |
| 45    | 31.0625           | 29.5625           | 10     | 7775.1  | 482.3089 | 8094.936       | 8505.673       |
| 46    | 30.875            | 29.375            | 10     | 7775.1  | 482.3089 | 8144.095       | 8559.964       |
| 47    | 30.6875           | 29.1875           | 10     | 7775.1  | 482.3089 | 8193.856       | 8614.953       |



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| TRACK         | RADIUS<br>(side0) | RADIUS<br>(side1) | BLOCKS | BYTES   | RPM            | FCI<br>(side0) | FCI<br>(side1) |
|---------------|-------------------|-------------------|--------|---------|----------------|----------------|----------------|
| 48            | 30.5              | 29                | 9      | 6997.59 | 535.8988       | 7419.805       | 7803.588       |
| 49            | 30.3125           | 28.8125           | 9      | 6997.59 | 535.8988       | 7465.701       | 7854.371       |
| 50            | 30.125            | 28.625            | 9      | 6997.59 | 535.8988       | 7512.168       | 7905.818       |
| 51            | 29.9375           | 28.4375           | 9      | 6997.59 | 535.8988       | 7559.217       | 7957.945       |
| 52            | 29.75             | 28.25             | 9      | 6997.59 | 535.8988       | 7606.859       | 8010.763       |
| 53            | 29.5625           | 28.0625           | 9      | 6997.59 | 535.8988       | 7655.105       | 8064.287       |
| 54            | 29.375            | 27.875            | 9      | 6997.59 | 535.8988       | 7703.968       | 8118.531       |
| 55            | 29.1875           | 27.6875           | 9      | 6997.59 | 535.8988       | 7753.458       | 8173.510       |
| 56            | 29                | 27.5              | 9      | 6997.59 | 535.8988       | 7803.588       | 8229.238       |
| 57            | 28.8125           | 27.3125           | 9      | 6997.59 | 535.8988       | 7854.371       | 8285.732       |
| 58            | 28.625            | 27.125            | 9      | 6997.59 | 535.8988       | 7905.818       | 8343.006       |
| 59            | 28.4375           | 26.9375           | 9      | 6997.59 | 535.8988       | 7957.945       | 8401.078       |
| 60            | 28.25             | 26.75             | 9      | 6997.59 | 535.8988       | 8010.763       | 8459.965       |
| 61            | 28.0625           | 26.5625           | 9      | 6997.59 | 535.8988       | 8064.287       | 8519.682       |
| 62            | 27.875            | 26.375            | 9      | 6997.59 | 535.8988       | 8118.531       | 8580.248       |
| 63            | 27.6875           | 26.1875           | 9      | 6997.59 | 535.8988       | 8173.510       | 8641.682       |
| 64            | 27.5              | 26                | 8      | 6220.08 | 602.8861       | 7314.878       | 7736.891       |
| 65            | 27.3125           | 25.8125           | 8      | 6220.08 | 602.8861       | 7365.095       | 7793.091       |
| 66            | 27.125            | 25.625            | 8      | 6220.08 | 602.8861       | 7416.006       | 7850.113       |
| 67            | 26.9375           | 25.4375           | 8      | 6220.08 | 602.8861       | 7467.625       | 7907.977       |
| 68            | 26.75             | 25.25             | 8      | 6220.08 | 602.8861       | 7519.968       | 7966.699       |
| 69            | 26.5625           | 25.0625           | 8      | 6220.08 | 602.8861       | 7573.051       | 8026.301       |
| 70            | 26.375            | 24.875            | 8      | 6220.08 | 602.8861       | 7626.887       | 8086.800       |
| 71            | 26.1875           | 24.6875           | 8      | 6220.08 | 602.8861       | 7681.495       | 8148.219       |
| 72            | 26                | 24.5              | 8      | 6220.08 | 602.8861       | 7736.891       | 8210.578       |
| 73            | 25.8125           | 24.3125           | 8      | 6220.08 | 602.8861       | 7793.091       | 8273.898       |
| 74            | 25.625            | 24.125            | 8      | 6220.08 | 602.8861       | 7850.113       | 8338.203       |
| 75            | 25.4375           | 23.9375           | 8      | 6220.08 | 602.8861       | 7907.977       | 8403.516       |
| 76            | 25.25             | 23.75             | 8      | 6220.08 | 602.8861       | 7966.699       | 8469.859       |
| 77            | 25.0625           | 23.5625           | 8      | 6220.08 | 602.8861       | 8026.301       | 8537.259       |
| 78            | 24.875            | 23.375            | 8      | 6220.08 | 602.8861       | 8086.800       | 8605.739       |
| 79            | 24.6875           | 23.1875           | 8      | 6220.08 | 602.8861       | 8148.219       | 8675.328       |
| side 0 blocks |                   |                   |        | 800     | max fci side 0 |                | 8224.565       |
| side 1 blocks |                   |                   |        | 800     | max fci side 1 |                | 8675.328       |
| total blocks  |                   |                   |        | 1600    | min fci side 0 |                | 7314.878       |
| total bytes   |                   |                   |        | 819200  | min fci side 1 |                | 7736.891       |

 apple computer inc.

SIZE  
A

DRAWING NUMBER  
699-0285-A

SCALE:

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